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(12) # EUROPEAN PATENT SPECIFICATION

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(54) **Refrigerator.**

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US-A- 4 183 734
US-A- 4 413 670
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Description

The present invention relates to refrigerators.

Refrigeration at about ambient temperature is currently achieved by using the compression cycle with halogenated hydrocarbons such as freon (Registered Trade Mark) gas as the refrigerating medium. Freon gas is compressed and the heat of compression is conducted to atmosphere thereby causing the gas to condense to a liquid. The liquid freon is then passed to the inside of an insulating chamber where it is allowed to expand and evaporate thereby cooling the chamber. The expanded freon gas then returns to a compressor for the cycle to be repeated.

Problems appear to arise when these known refrigerators wear out since when they are recycled or scrapped it is believed that the freon type gases are released thereby damaging the ionosphere.

An alternative cycle is available in domestic refrigeration and is known as the ammonia adsorption cycle. However, it is less efficient and often less reliable being dependent on the containment of hydrogen gas.

US-A-4 183 734 discloses a refrigerator comprising a chamber containing a bed of adsorbent material and a compressible gas capable of being adsorbed under pressure by the adsorbent material and desorbed therefrom when the pressure is reduced. Means are provided for alternately compressing the gas within the chamber thus creating a temporary cold zone within the chamber. Thermal connection means are provided for connecting the cold zone to a location to be refrigerated. Unfortunately, such a device is unable to provide a permanent cold zone.

It is an aim of the present invention to provide a refrigerator which utilises the cold zone(s) which are created when certain gases are adsorbed by and then desorbed from a bed of adsorbent material.

According to one aspect of the present invention a refrigerator comprises a sealed chamber containing a bed of an adsorbent material and a compressible gas capable of being adsorbed under pressure by said adsorbent material and desorbed from said adsorbent material when said pressure is reduced, means for alternately compressing and decompressing the gas within the chamber thus creating a permanent cold zone within the chamber and means for thermally connecting the cold zone to a location to be refrigerated.

According to a further aspect of the present invention there is provided a method of refrigeration comprising the steps of:

a) compressing a gas within a sealed chamber containing a bed of an adsorbent material such that some at least of the gas is adsorbed by said adsorbent material;

b) removing heat generated by the adsorption step;

c) decompressing the gas within the chamber such that the gas is desorbed from the adsorbent material;

d) repeating steps a), b), and c) until a permanent cold zone is created in the adsorbent material; and

e) thermally connecting said cold zone to a location to be refrigerated.

An embodiment of the invention will now be described by way of example, reference being made to the Figure of the accompanying diagrammatic drawing which is a schematic sketch of a refrigerator according to the present invention.

As shown, a refrigerator 1 includes a chamber in the form of a hollow cylinder 2 within which is located a bed of an adsorbent material 3, for example, a zeolite having a high heat adsorption such as 13X or 5A type. Also located within the cylinder 2 is a pre-selected volume of a gaseous medium such as carbon dioxide which has a high affinity for the adsorbent material 3 and is readily compressible.

As shown, the cylinder is arranged vertically and at its lower end and slidably received therein is a piston extending from a compressor 6 preferably of a type totally sealed from the atmosphere. The piston is adapted to seal the carbon dioxide within the cylinder 2 and when reciprocated alternately to compress and decompress the carbon dioxide.

Adjacent the lower end of the cylinder 2 there is located thermally connecting means in the form of plates 7 which extend from the outer surface of the cylinder 2 to enter the interior of a compartment 8 which interior is to be cooled.

At its upper (as shown) end attached to the cylinder 2 are a plurality of cooling fins 4.

In use, the compressor 6 is started and upward (as shown) extended movement of the piston into the interior of the cylinder 2 compresses the carbon dioxide. The carbon dioxide is initially adsorbed by the bed of material 3 at the lower end of the zeolite bed thereby generating heat. The heat generated is carried upward by further incoming carbon dioxide with the result that when the compression stroke of the compressor is completed a heat spot is formed at the extreme upper end of the cylinder 2. This heat spot is dissipated by means of the cooling fins 4 to ambient atmosphere.

During downward (as shown) retracted movement of the piston within the interior of the cylinder 2 the decompression of the carbon dioxide takes place which carbon dioxide is desorbed from the adsorbent material 3 leading to a net cooling of the adsorbent material 3. Because some of the heat

has been dissipated by means of the cooling fins 4 some of the material 3 will become very cool and it has been found over a number of cycles of the compressor a cold spot is formed within the bed of adsorbent material 3 close to the point of entry of the piston (the lower end of the cylinder 2). This cold spot is thermally linked to the interior of the compartment 8 by plates 7 thereby allowing the interior of the compartment 8 to be refrigerated.

Particular advantages of the embodiment described above are (a) the materials employed are all environmentally friendly so that the ultimate disposal of the refrigerator presents no problems; and (b) the system is a closed system requiring no constant replacement of adsorbent or gas.

Claims

1. A refrigerator (1) comprising a sealed chamber containing a bed of an adsorbent material (3) and a compressible gas capable of being adsorbed under pressure by said adsorbent material (3) and desorbed from said adsorbent material (3) when said pressure is reduced, means for alternately compressing and decompressing the gas within the chamber thus creating a permanent cold zone within the chamber and means (7) for thermally connecting the cold zone to a (8) location to be refrigerated.

2. A refrigerator as claimed in Claim 1, characterised in that the chamber is a cylinder (2) and the means for alternately compressing and decompressing the gas is a piston slidable within the cylinder (2).

3. A refrigerator as claimed in Claim 2, characterised in that the thermally connecting means is a plurality of conductive plates (7) located adjacent the cylinder (2) and in alignment with the cold zone and extending within the interior of a compartment (8) to be refrigerated.

4. A refrigerator as claimed in any one of Claims 1 to 3 , characterised in that the adsorbent material (3) is a zeolite and the compressible gas is carbon dioxide.

5. A refrigerator as claimed in any one of Claims 2 to 4, characterised in that the cylinder (2) is vertically orientated and the piston arranged to be slidable along the lower portion of the cylinder (2).

6. A refrigerator as claimed in Claim 5, characterised in that at the upper end of the cylinder (2) cooling fins (4) are attached to the cylinder (2).

7. A method of refrigeration comprising the steps of:
   a) compressing a gas within a sealed chamber containing a bed of an adsorbent material (3) such that some at least of the gas is adsorbed by said adsorbent material (3);
   b) removing heat generated by the adsorption step;
   c) decompressing the gas within the chamber such that the gas is desorbed from the adsorbent material (2);
   d) repeating steps a), b), and c) until a permanent cold zone is created in the adsorbent material (2); and
   e) thermally connecting said cold zone to a location (8) to be refrigerated.

Patentansprüche

1. Eine Kühlvorrichtung (1) mit einer abgedichteten Kammer, die ein Bett aus einem Adsorbermaterial (3) und ein komprimierbares Gas enthält, das unter Druck von dem Adsorbermaterial (3) adsorbiert und von dem Adsorbermaterial (3) desorbiert werden kann, wenn der Druck reduziert wird, Mitteln zum abwechselnden Komprimieren und Dekomprimieren des Gases innerhalb der Kammer, wodurch eine permamente kalte Zone innerhalb der Kammer erzeugt wird, und Mitteln (7) zur thermischen Verbindung der kalten Zone mit einem zu kühlenden Ort (8).

2. Eine Kühlvorrichtung wie in Anspruch 1 beansprucht, dadurch **gekennzeichnet,**
daß die Kammer ein Zylinder (2) ist, und daß das Mittel zum abwechselnden Komprimieren und Dekomprimieren des Gases ein Kolben ist, der innerhalb des Zylinders (2) gleitbar ist.

3. Eine Kühlvorrichtung wie in Anspruch 2 beansprucht dadurch **gekennzeichnet,**
daß das thermisch verbindende Mittel eine Vielzahl von leitfähigen Platten (7) darstellt, die benachbart dem Zylinder (2) und in Ausrichtung mit der kalten Zone angeordnet sind sowie sich im Inneren eines zu kühlenden abgeteilten Raumes (8) erstrecken.

4. Eine Kühlvorrichtung wie in einem der Ansprüche 1 bis 3 beansprucht,
dadurch **gekennzeichnet,**
daß das Adsorbermaterial (3) ein Zeolith und das komprimierbare Gas Kohlendioxid ist.

5. Eine Kühlvorrichtung wie in einem der Ansprüche 2 bis 4 beansprucht,
dadurch **gekennzeichnet,**

daß der Zylinder (2) vertikal orientiert ist, und daß der Kolben so angeordnet ist, daß er entlang des unteren Bereiches des Zylinders (2) gleitbar ist.

6. Eine Kühlvorrichtung wie in Anspruch 5 beansprucht, dadurch **gekennzeichnet,**
daß am oberen Ende des Zylinders (2) Kühlrippen (4) am Zylinder (2) angebracht sind.

7. Ein Kühlverfahren, welches die Schritte umfaßt,
a) daß ein Gas innerhalb einer abgedichteten Kammer, die ein Bett aus einem Adsorbermaterial (3) enthält, komprimiert wird, so daß wenigstens etwas des Gases durch das Adsorbermaterial (3) adsorbiert wird,
b) daß durch den Adsorptionsschritt erzeugte Wärme abeführt wird,
c) daß das Gas innerhalb der Kammer dekomprimiert wird, so daS das Gas von dem Adsorbermaterial (2) desorbiert wird,
d) daß die Schritte a), b) und c) wiederholt werden, bis eine permanente kalte Zone in dem Adsorbermaterial (2) erzeugt ist, und
e) daß die kalte Zone thermisch mit einem zu kühlenden Ort (8) verbunden wird.

Revendications

1. Réfrigérateur (1) comprenant une chambre étanche qui contient un lit d'un matériau adsorbant (3) et un gaz compressible qui peut être adsorbé sous pression par le matériau adsorbant (3) et désorbé de ce matériau (3) lorsque la pression est réduite, un dispositif destiné à comprimer et décomprimer en alternance le gaz contenu dans la chambre en créant une zone froide permanente dans la chambre, et un dispositif (7) de raccordement thermique de la zone froide à un emplacement (8) à réfrigérer.

2. Réfrigérateur selon la revendication 1, caractérisé en ce que la chambre est un cylindre (2), et le dispositif de compression et de décompression en alternance du gaz est un piston qui peut coulisser dans le cylindre (2).

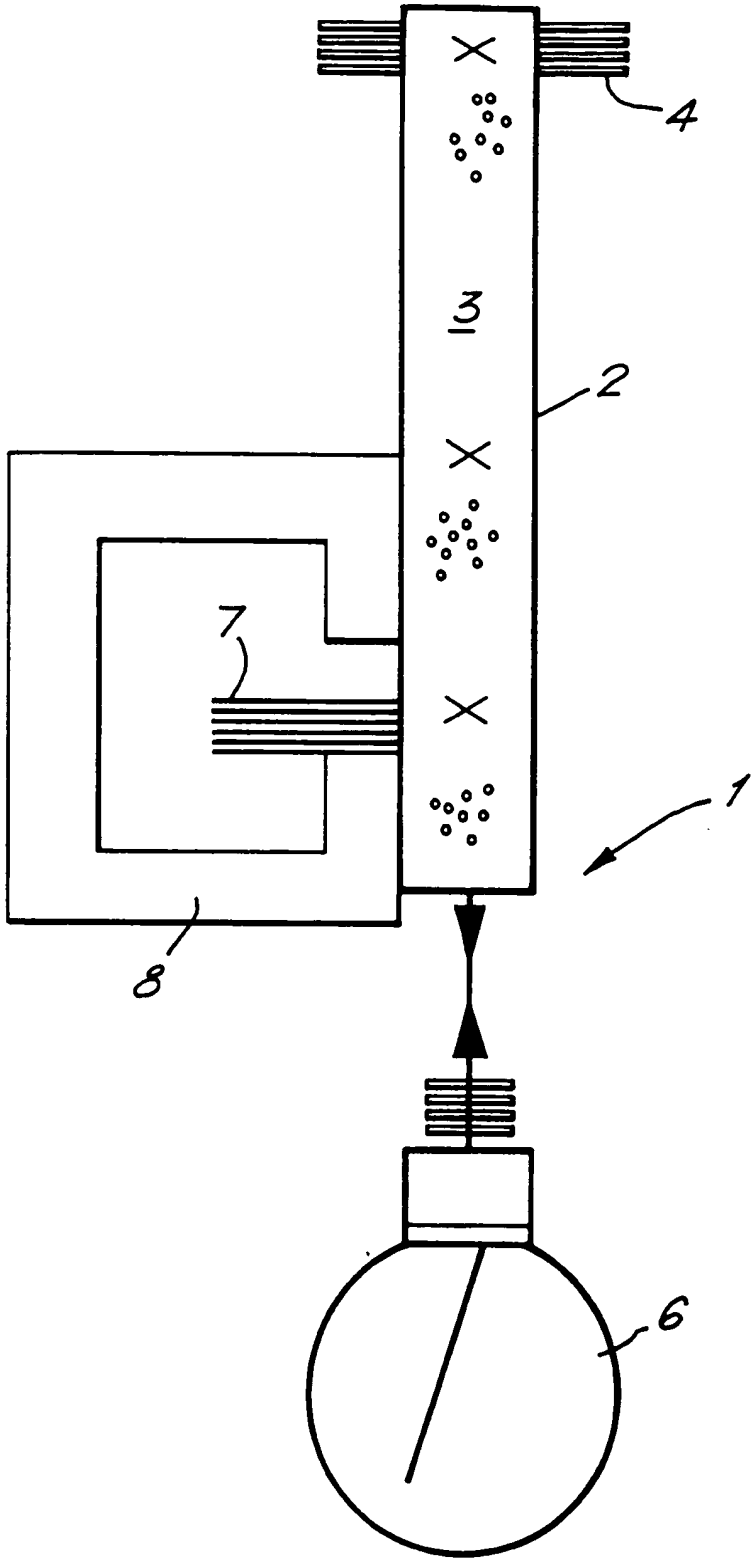
3. Réfrigérateur selon la revendication 2, caractérisé en ce que le dispositif de raccordement thermique est formé par plusieurs plaques conductrices (7) placées près du cylindre (2) et dans l'alignement de la zone froide et pénétrant à l'intérieur d'un compartiment (8) qui doit être réfrigéré.

4. Réfrigérateur selon l'une des revendications 1 à 3, caractérisé en ce que le matériau adsorbant (3) est une zéolite et le gaz compressible est l'anhydride carbonique.

5. Réfrigérateur selon l'une des revendications 2 à 4, caractérisé en ce que le cylindre (2) a une orientation verticale et le piston est disposé afin qu'il coulisse le long de la partie inférieure du cylindre (2).

6. Réfrigérateur selon la revendication 5, caractérisé en ce que, à l'extrémité supérieure du cylindre (2), des ailettes de refroidissement (4) sont fixées au cylindre (2).

7. Procédé de réfrigération qui comprend les étapes suivantes :
a) la compression d'un gaz dans une chambre étanche contenant un lit d'un matériau adsorbant (3) afin qu'une partie au moins du gaz soit adsorbée par le matériau adsorbant (3),
b) l'extraction de chaleur dégagée par l'étape d'adsorption,
c) la décompression du gaz dans la chambre afin que le gaz soit désorbé du matériau adsorbant (2),
d) la répétition des étapes (a), (b) et (c) jusqu'à la création d'une zone froide permanente dans le matériau adsorbant (2), et
e) le raccordement thermique de la zone froide à un emplacement (8) qui doit être réfrigéré.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